Southern Cumberland Plateau Regional Water Supply Planning Pilot Study

04 December 2009

Benjamin L. Rohrbach, P.E.
Chief, Hydrology and Hydraulics
U.S. Army Corps of Engineers
Nashville District

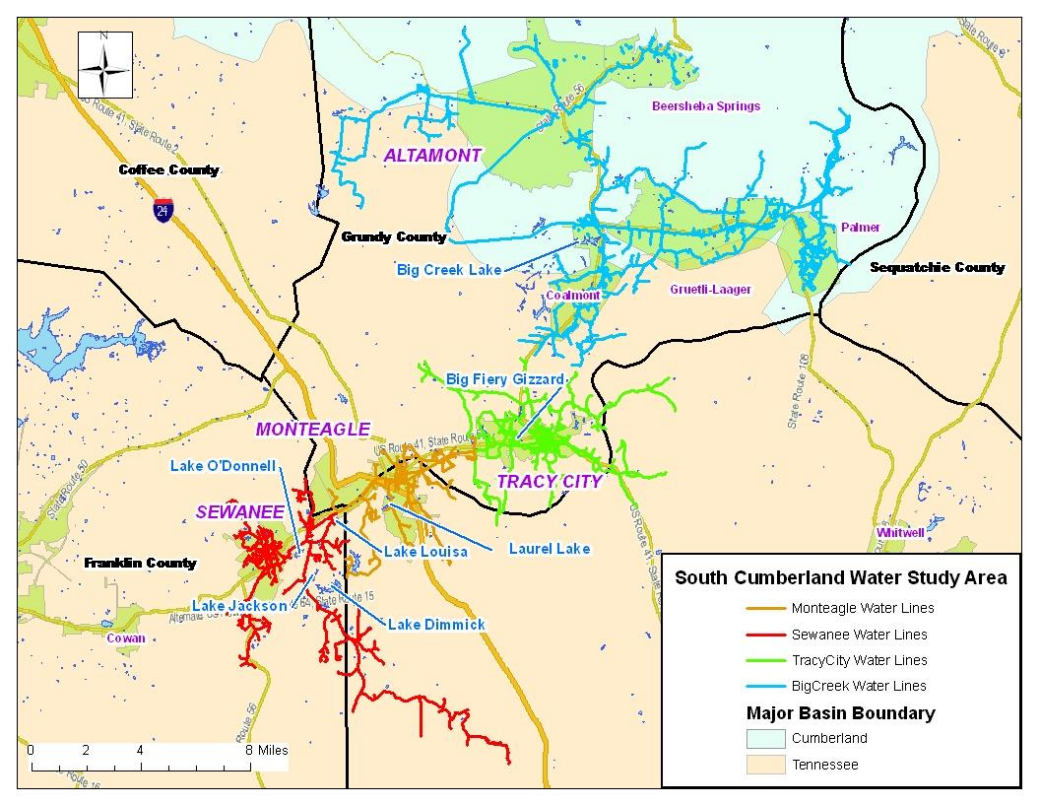
US Army Corps of Engineers
BUILDING STRONG®

Presentation Outline

- Phase I Overview
- Phase II Tasks
- Phase II Progress
- Questions and Comments

Phase I Overview

- Collection and documentation of existing water source information, use, and demand for study area
- Collection and documentation of existing water distribution system and wastewater discharge information
- Development of GIS Database



Phase II Tasks

- Regional Drought Evaluation
- Existing Water Source Yield Analyses
- Water Demand Management Strategies
- Alternative Water Source Identification
- Alternative Water Source Yield Analyses

Phase II Progress

- Regional Drought Evaluation
  - Utilizes Standardized Precipitation Index – reflecting probability of occurrence for rainfall totals of selected duration
  - Practical limits of -4 to 4, beyond which the probability of occurrence is too low to detect within standard periods of record

SPI Values	
2.0+	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and less	extremely dry

Phase II Progress

- Regional Drought Evaluation
  - Study Area Precipitation Record: 1928 – 2009
  - SPI computed at multiple durations: 1 month to 60 months
  - Critical drought duration varies according to reservoir size and shape, demand, and watershed characteristics

Phase II Progress

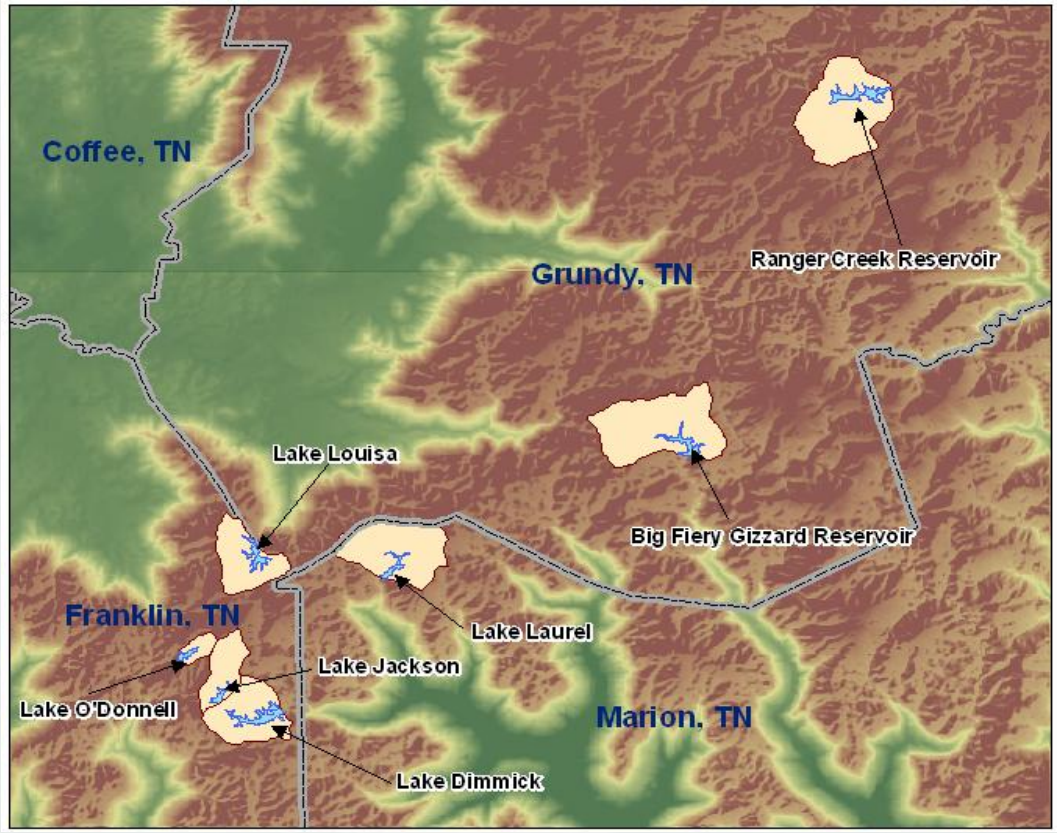
Drought	3	6	9	12	15	18	24	30	36	42	48	54	60
1930-1934	-2.50	-3.02	-3.20	-3.27	-3.02	-3.08	-2.92	-2.52	-1.96	-1.92	-2.09	-1.91	-1.92
1939-1942	-2.65	-2.81	-2.51	-2.04	-2.06	-1.97	-2.41	-2.38	-2.53	-2.33	-2.13	-2.32	-2.22
1944-1945	-3.98	-2.78	-2.00	-1.95	-1.39	-1.54	-1.56	-1.26	-1.32	-1.42	-1.81		
1960-1961	-2.56	-2.50	-2.04	-1.88	-1.55	-1.45	--	--	--	--	--	--	--
1963-1964	-3.22	-1.79	-1.21	--	--	--	--	--	--	--	--	--	--
1986-1988	-2.14	-2.65	-2.46	-2.29	-2.65	-2.49	-1.93	-1.95	-1.92	-2.01	-1.96	-2.06	-1.78
2007-2009	-2.97	-2.84	-3.31	-3.07	-3.24	-2.80	-2.91	-2.76	-2.63	-2.25	-2.02	-1.89	-1.19

Critical 3 to 60 months duration SPI values for droughts in the Southern Cumberland Plateau Study Area

- Early 1930's and 2007-2009 droughts are dominant droughts for 6-36 month duration
- SPI value of -3.0 corresponds to a cumulative probability of 0.0014

Phase II Progress

- Existing Water Source Yield Analyses



Phase II Progress

- Existing Water Source Yield Analyses
  - Developed hydrologic models (HEC-HMS) of watersheds with historical precipitation record input
  - Generated synthetic inflow sequences to reservoirs
  - Utilized sequent peak algorithm to analyze inflow sequence and identify critical drought
  - Computed firm yield using reservoir storage capacity and sequent peak algorithm

Phase II Progress

- Existing Water Source Yield Analyses
  - Sequent Peak Algorithm – cumulative tracking of the daily water balance for a reservoir

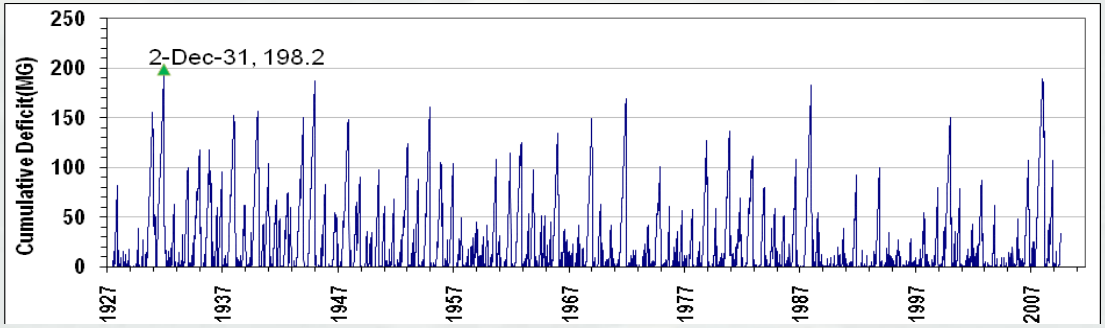
$$K_t = (D_t - Q_t) + K_{t-1}$$

Where:
K_t = cumulative deficit at time (t)
D_t = demand (yield) at time (t)
Q_t = inflow at time (t)
K_{t-1} = cumulative deficit at time (t-1)

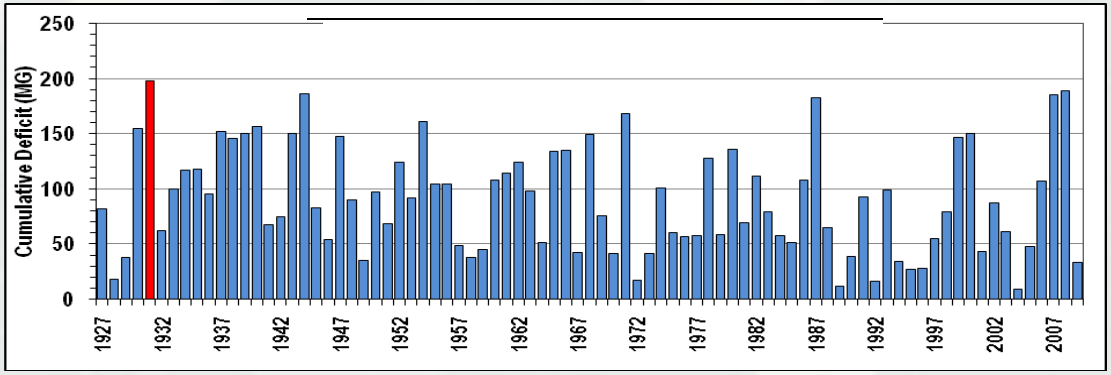
  - Firm yield is calculated by solving for the yield at which cumulative deficit is exactly equal to the reservoir's available storage capacity

Phase II Progress

- Existing Water Source Yield Analyses



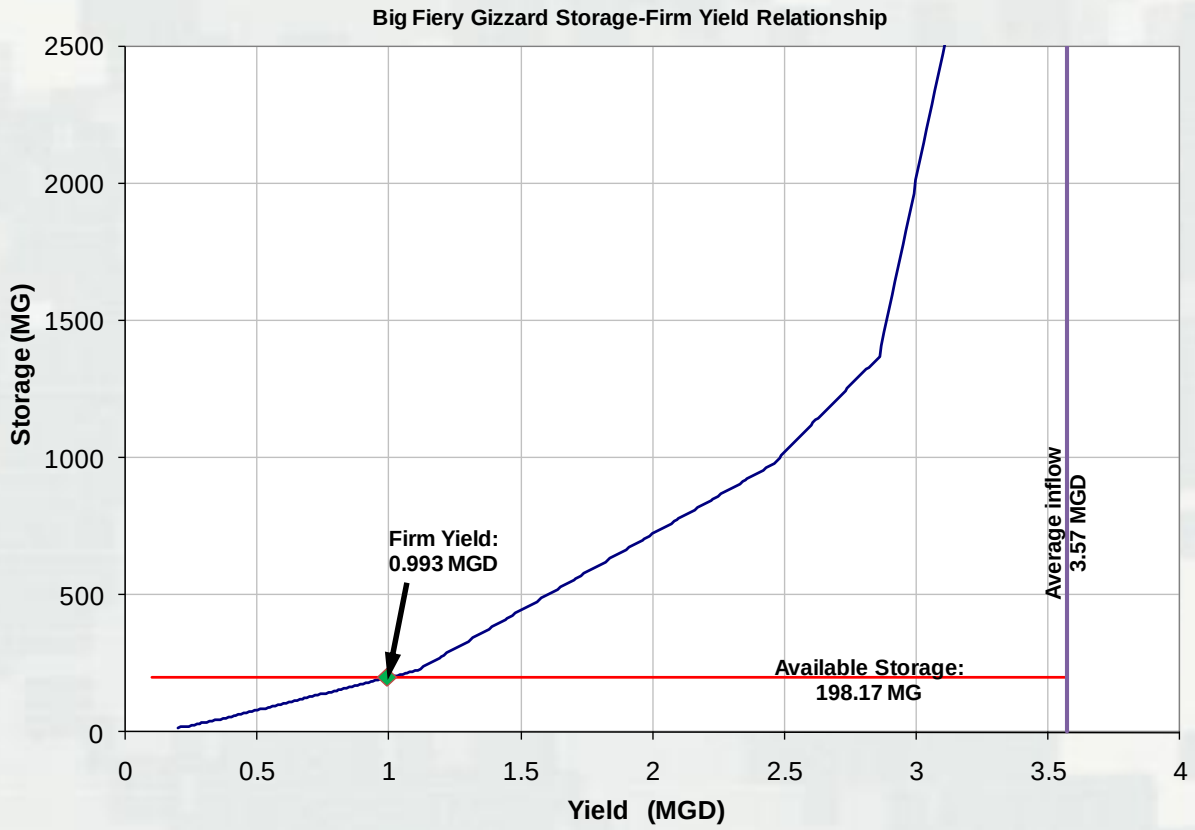
Sequent Peak Algorithm (SPA) Plot at a Daily Time-step



Annual Maximum Cumulative Deficit Plot from SPA

Phase II Progress

- Existing Water Source Yield Analyses



Firm Yield Computations are Dependent Upon Accurate Estimates of Available Storage in the Reservoir

Phase II Progress

- Additional Data Needs for Firm Yield Analyses:
  - Sewanee
    - Confirmation on Storage Capacity for All Reservoirs (Discrepancy between Safe Dams and CTI Estimates)
  - Monteagle
    - Normal Pool Elevation for Lake Louisa
    - Lowest Withdrawal Elevation for Lake Louisa
  - Tracy City - None
  - Big Creek
    - Stage-Storage Curve for Big Creek (Ranger Creek) Lake
    - Lowest Withdrawal Elevation

Phase II Progress

- Existing Water Source Yield Analyses

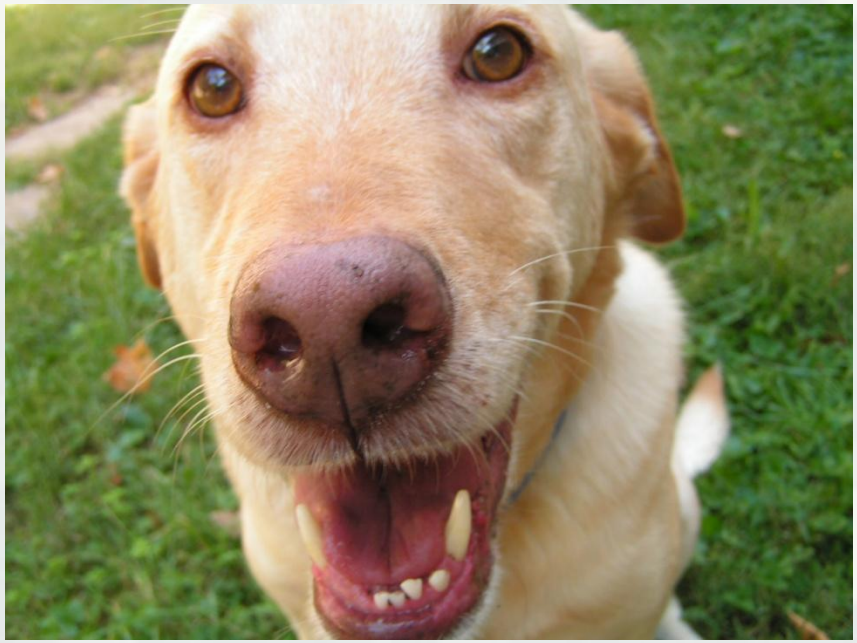
Utility District	Current Average Demand (MGD)	Reservoir	Storage Capacity (MG)	Average Inflow (MGD)	Release Requirement (MGD)	Firm Yield (MGD)
Big Creek	**1.00**	Ranger Creek Reservoir	300	3.28	0	**1.145**
Monteagle	**0.35**	Laurel Lake	91.24	2.5	0	**0.493**
		Lake Louisa	212.78	1.58	0	**0.653**
Sewanee	**0.325**	Lake O'Donnell	55.82	0.37	0	**0.169**
		Lake Jackson	113.89	1.07	0	**0.403**
		Lake Dimmick	51.25	2.52	0	**0.282**
Tracy City	**0.45**	Big Fiery Gizzard Reservoir	198.17	3.57	0.646	**0.347**

Phase II Progress

- Water Demand Management Strategies
  - ►Existing Practices and Plans Reviewed
  - ►Evaluation of Active and Passive Measures Planned
    - Reduce Unaccounted for Water Loss
      - ▷ Metering Improvement, Line Flushing Reduction
      - ▷ Leak Detection and Repair
    - Conservation Pricing
    - New Construction Standards
    - Retrofit, Replacement, Rebate Programs
    - Education

Phase II Progress

- Alternative Water Source Identification
  - ►Existing Source Improvement
    - Raise Big Fiery Gizzard Lake
    - Optimize Water Sharing between Utilities
  - ►New Source Development
    - South Pittsburgh Pipeline
    - Big Creek Lake
    - Ramsey Lake
    - Harrison Ferry Mountain Water Project
  - ►Yield Analyses not yet Undertaken



Questions/Comments??

Benjamin L. Rohrbach, P.E.
Chief, Hydrology & Hydraulics Branch
Phone: (615) 736-7497
Email: ben.rohrbach@usace.army.mil